EFFECT OF MINERAL NUTRIENTS ON SELECTED VEGETABLE CROPS

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CHAPTER I

INTRODUCTION

INTRODUCTION

In a country like India, agriculture is central to the national economy. Nearly half of our gross national product is generated by agriculture which presently depends fundamentally on the new varieties of high yielding crops. These, in turn, would provide their maximum benefits only with assured supply of fertilizers and irrigation.

Vegetable growing occupies a significant position among the branches of agriculture and has increased in importance in recent years. As compared to other crops, many vegetables can be grown throughout the year and some green vegetables are even ready within 45-60 days. Therefore, many of them can be raised profitably twice or even thrice in a year. In India, the per capita consumption of vegetables is many times more than in the affluent countries of the western world due to two reasons: first, the vegetarian habit of a very large section of the population and secondly, the much lower cost of the common vegetables compared with other commodities, such as meat, fish and milk products.

The picture is not expected to change much in the near future. Consequently, vegetable consumption is not likely to decline in India. In fact, with assured demand and remunerative prices, farmers shall continue vegetable production seriously. However, when prices fall abruptly, it does not take long to quit and switch over to other crops.

Extension work, teaching and research activities concerned with vegetables are expanding rapidly throughout the world partly because these services are increasing generally for all branches of agriculture and partly because vegetable production and marketing is gradually attaining the status of an industry. But it must be admitted that by and large the approach of farmers in India, is mostly primitive. The conservative farmer is less readily willing to adopt the new varieties. Even when he is convinced of their superior performance, he is reluctant to apply the recommended high doses of fertilizers without which optimum yields would not be possible.

Therefore, for our country the implementation of policies depending on new agricultural technologies requires a comprehensive and co-ordinated system of providing inputs (including fertilizer), teaching new methods of cultivation, providing credit and facilitating the marketing of farm output. Such a system must be staffed by trained personnel. The task of effective change is complicated by the fact that most Indian farms (and these account for a fourth of agricultural land) are smaller than two hectares (five acres). The small farmers are poor and are wary of experimentation. However, if they can be persuaded to innovate and if they are supported by the necessary institutions, they can also make effective use of fertilizers, pesticides and water like the farmers with large holdings (Mellor, 1976).

Uttar Pradesh, an overwhelmingly rural state, has taken giant strides in agriculture during the last ten years. It is now producing not only surplus wheat and pulses but also oilseeds, potatoes and sugarcane (Kala, 1976); but vegetable production is far from satisfactory. The situation is, however, showing signs of improvement. Of late, the farmers with irrigated land holdings have responded with great enthusiasm to the efforts of the State Agriculture Department to popularise the high yielding and disease resistant varieties of vegetables.

It may be added that the western part of this state, where Aligarh is located, is suited for vegetable growing due to high soil fertility. Assured marketability on account of dense population, proximity of large urban communities and good road and rail transportation facilities act as further incentives. Aligarh is thus ideally suited for research on various common vegetables in addition to cereals and other crops.

Work done here during the last ten years is mainly concerned with various aspects of mineral nutrition of a number of crops like cereals (Safaya, 1971; Samiullah, 1971; Afridi and Samiullah, 1973; Qaseem, 1975; Samiullah and Afridi, 1975; Afridi et al., 1976,b, 1978,a; Abbas, 1978; Inam 1978; Qaseem et al., 1978), oil crops (Naqvi, 1976; Afridi et al., 1976,a; Afridi et al., 1977; Naqvi et al., 1977; Parvaiz, 1979), medicinal plants (Afaq, 1978; Wasiuddin, 1979; Wasiuddin et al., 1979) and vegetables (Khalique, 1975; Siddiqui, 1978). It has been reviewed from time to time (Afridi and Wasiuddin, 1977; Afridi et al., 1978,b; Afridi, 1980).

A critical study of these publications and other available literature reveals that work on the mineral requirements of most of the vegetables grown in the region is meagre. It has, therefore, been decided to undertake field trials on a few of the important vegetables grown around Aligarh (carrot, lettuce, okra, radish, spinach and turnip) to assess their optimum fertilizer requirements. As vegetables are known to consume large quantities of fertilizers, it is also proposed to include a study of the feasibility of fertilizer economy by using the technique of foliar nutrition so as to cut down the cost of production, if possible.

CHAPTER II

REVIEW OF LITERATURE

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2. REVIEW OF LITERATURE

2.1 Historical background of mineral nutrition of plants

In all ages, the growth of plants has interested thoughtful men. Plants have fascinated man not only for their beauty but also for their usefulness in everyday life. The ever abounding interest of man in plants and in their growth and welfare through the centuries is, therefore understandable. There was an extensive literature on agriculture in Roman times which maintained a pre-eminent position until comparatively recently.

In spite of this, it is surprising that the approach of scientists towards plants remained rather causal, unsystematic and unscientific until the beginning of the 19th century A.D. No doubt, there is mention in literature of such eminent investigators as Nicholas of Cusa in the 15th century; Van Helmont, Glauber and Woodward in the 17th century; and Hales, Tull, Priestley, Ingen-Housz and Senebier in the 18th century (Bould, 1963). Between 1770 and 1800 considerable work was done on the effects of vegetation on air, but its agricultural significance was not recognised until later (Russell, 1950).

However, insight into the working of plants had to await the great strides taken by chemistry in the 19th century. These discoveries stimulated interest in the study of the relation between soil and plant growth beginning with de Saussure (1804) who is rightly called the "father of modern quantitative plant physiology". Later, within a span of a few decades, Boussingault, Lawes and Gilbert, Liebig, Sachs, Ville and others made outstanding contributions to the knowledge of plant nutrition; and by about 1865, the list of the major essential nutrient elements was completed and universally accepted (Hewitt, 1963)

2.2 NPK as fertilizers

In vegetable growing, commercial fertilizers are very important and their use is increasing every year. This increase is partly due to the shortage of manure and partly to the increasing knowledge of the value of commercial fertilizers themselves.

Among the so-called macronutrients, nitrogen, phosphorus and potassium have received much more attention than others as they are removed in larger quantities by crops. Consequently, application of NPK to the field is essential for ensuring good growth and better yield.

Due to economic considerations as well as scientific curiosity, considerable effort has been made to evaluate the NPK needs of particular varieties of crop plants under various environmental conditions during the last 150 years in different countries of the world.

It is, however, true that enough attention has not been paid to the nutritional requirement of vegetable crops inspite of their established importance in the daily life of man. From this point of view, the six vegetable crops selected as the topic of this dissertation, are no exception. The following brief review of literature will reveal how little work has been undertaken on the NPK requirements of the various varieties of these vegetables not only in India, but also in other countries.

2.3 Physiological role of NPK

2.3.1 Nitrogen

It is the most abundant gas in the atmosphere, constituting about 80 per cent by volume. Except for a very few microorganisms, however, it is not utilised directly by plants or animals. In nature, nitrates or ammonium salts formed in the soil by various agents participating in the so-called "nitrogen cycle" provide a source of nitrogen. Of the elements commonly supplied through commercial fertilisers, nitrogen has the quickest and most pronounced effect. It tends to encourage the development of the vegetative, above ground portion of the plant and imparts a deep green colour to the leaves. It increases plumpness in seeds and tends to produce succulence in fruits, a quality of great importance in many vegetables.

Its most important role in the plants is its presence in the structure of the protein molecules. In addition, nitrogen is found in such important compounds as purines, pyrimidines, porphyrins and co-enzymes. Purines and pyrimidines are constituents of nucleic acids, which determine the entire make up of generations. Similarly, chlorophyll is also a nitrogen-containing compound. Other classes of nitrogenous compounds found in plants include aminoacids, nucleosides, nucleotides, alkaloids and vitamins etc. In short, through these molecules, nitrogen is involved in almost every phase of plant growth and development.

2.3.2 Phosphorus

Phosphorus is another important constituent of plant tissues and is responsible for various metabolic activities. It is not present in abundance in most soils and, even when present, most of it is "fixed" and thus unavailable to plants. Like nitrogen, the requirement of phosphorus for growth and development continues throughout the life span of the plant.

Some of the important cell constituents that have phosphorus as their component include phospholipids, nucleosides and nucleotides, nucleic acids and nucleoproteins, as well as many co-enzymes. Phosphorus plays a key role through these important compounds in energy transfer in respiration and photosynthesis. Similarly its involvement in the transfer of genetic characters from one generation to another can not be over-emphasised.

2.3.3 Potassium

It is the only monovalent cation essential for plants. Unlike all the major elements, potassium does not enter into the composition of any of the plant constituents. However, it is abundantly present in soluble form in the cytoplasm and in the vacuolar sap of meristematic tissues and metabolically active regions (buds, young leaves and meristems), and is known to be a co-factor (activator) for a number of enzyme systems (Devlin, 1975).

2.4 NPK requirement of vegetables

Vegetables require heavy doses of organic as well as inorganic manures which should be applied according to the pattern of their root growth. (Chauhan, 1968). For example, carrot, okra, radish and turnip which have quick growing roots, the soil should be deeply fertilised so that nutrients may be readily available to the roots of the plants as they grow. On the other hand, for green vegetables, like lettuce and spinach, with a relatively shallow root system, the upper layers of soil should contain enough nutrients.

In the following pages an attempt has been made to review briefly the available literature concerning the fertiliser requirements of the six selected vegetables, namely carrot, radish, turnip, lettuce, spinach and okra, under various agroclimates, with particular emphasis on the work done in India.

As mentioned earlier, vegetable growing has not been given due consideration as a serious agricultural practice worthy of investigations on scientific lines like the cultivation of cereals or other crops of economic importance. Very little authentic, scientific literature on vegetable growing is available. Popular, as well as semi-technical, literature on vegetables may be very useful for advertising the importance of vegetables for health and for encouraging their use in daily diet, but is of little scientific value.

Most of the information is available in the form of bulletins published by the Departments of Extension Education in Agricultural Colleges and Universities.

2.5 NPK effect on growth and yield of root crops

(a) Carrot

Thompson and Kelley (1957), in U.S.A., found that 280-300 quintals of carrot removed about 3 kg. of nitrogen, 18 kg. of phosphorus and 10 kg of potash.

20-25 metric tons of well rotted manure applied as basal dressing, 2 quintal of potassium as potassium sulphate and 1.5 quintal of superphosphate before sowing gave good yield.

Haworth and Cleaver (1960) reported that carrot seedlings from farm yard manure-treated plots at Wellesbourne (U.K.) contained more potassium than from plots which had received only mineral fertilisers including potassium sulphate. In sand culture, they reported that the increased amount of potassium in the nutrient medium increased the rate of growth. They concluded that the greater uptake of potassium by carrot seedlings on the farm yard manure-treated plots was largely responsible for their rapid growth.

According to Haworth *et al*. (1966), addition of farm yard manure (FYM) had good effect on yield of carrot at Wellesbourne (U.K.) than fertiliser alone. In the absence of farm yard manure, carrot yield was depressed. Farm yard manure-treated plants contained about twice as much potassium and about 30 per cent more phosphorus than those receiving inorganic fertilisers alone.

Islam and Rashid (1973) tested, in Pakistan, the tolerance of carrot to equeous solutions of urea at concentrations ranging from 4 lb to 26 lb/100 gallons.

The maximum concentration at which foliar symptoms of injury appeared in carrot was 12 lb/100 gallons.

Habben (1973,a) observed, in pot experiments applying nitrogen as ammonium nitrate, that nitrogen application enhanced top growth, nitrate accumulation and carotene content and decreased crude fibre content. Potassium, as potassium sulphate, at low rates limited root growth. At higher rates, it decreased the percentage of reducing sugars and increased that of sucrose. It also increased the crude fibre content.

In another publication, Habben (1973,b) concluded that root carotene content of carrots was increased by raising nitrogen levels, but no such effect was noted with potassium. With potassium application, percentage of reducing sugars decreased and that of non-reducing sugars increased. Nitrate accumulation was enhanced by nitrogen fertilization.

Kumar et al. (1974) studied the effect of nitrogen levels and sowing methods on nutritive value of carrot, at P.A.U., Ludhiana (Punjab). Nitrogen at 45, 60 or 75 kg/ha in combination with ridge, flat line and broadcast sowing was compared in a randomised block design. Sowing on ridges was best for the accumulation of carotene, iron and crude fibre contents; flat lines for protein, calcium, phospherus, water-soluble carbohydrates, minerals and dry matter; and broadcasting for carotene, calcium and other-extracts; while 60 kg N/ha favoured iron, phosphorus, water soluble carbohydrates, minerals, crude fibre and dry matter and 75 kg N/ha, protein content only. Application of 60 kg N/ha was optimum for producing nutrient-rich roots.

Lipari (1975) studied the response of carrot to 3 fertiliser levels with 3 plant densities and 2 row spacings. He found that there was a significant correlation between the yield of marketable roots and plant density. High density, increased yield and number of deformed or immature roots but decreased the number of marketable roots. Fertilising had no marked effect on marketable and unmarketable root yield.

Alekseeva and Kutsenko (1976) found that nitrogen at 60 kg/ha., P_2O_5 at 180 kg/ha and K_2O at 180 kg/ha gave the highest yield, increased the production of standard grade mother-plants by 8 per cent and reduced storage losses by 6.5 per cent, as compared with the no-fertiliser control.

Borna (1976) studied the response of carrot to various NPK rates ranging from 200-1200 kg/ha (2:2:3) and to irrigation. Irrigation generally increased the effectiveness of mineral fertilisers and their interaction had greater effect on marketable yield than on total yield.

Hansen (1976) studied for several years in factorial trials the effect of fertilisers on carrot in sandy soil. He noted that about 8 kg N/da, 8 kg P/da and 12 kg K/da were suitable. Excessive nitrogen dressing resulted in soil losses of potassium and magnesium and falls in carrot dry matter and phosphorus levels. Excessive potassium dressing led to increased infection by Centrospora acerina and a lower uptake of nitrogen, magnesium and calcium by carrots.

Krarup and Moretti (1976) studied the effect of NPK on carrot seed yield. They supplied 64, 128 or 192 kg N/ha; 100, 150 or 200 kg P_2O_5/ha and 50, 100 or 150 kg K_2O/ha. The highest seed yield was produced at the rate of 192 kg N, 150 kg P_2O_5 and 100 kg K_2O/ha.

Pankov (1976,a) found a close relationship between carrot yield and leaf nitrogen content in both pot and field experiments. He noted that 3.25 per cent leaf nitrogen content was required for high productivity. Nitrogen deficiency in the medium decreased the leaf nitrogen content but increased the content of phosphorus and potassium, resulting in an increase in dry matter and sugar content.

In a similar study, Pankov (1976,b) found a correlation between carrot yield and leaf phosphorus content. Optimal leaf phosphorus content in relation to plant growth and yield was determined to be 0.25-0.26 per cent. Phosphorus deficiency reduced yields but an increase in dry matter, sugar and carotene content was observed.

Finally Pankov (1976,c) reported a similar relationship between leaf potassium content and carrot yield as with leaf nitrogen content and leaf phosphorus content noted above, good plant growth and high yield being obtained only in plants with $>$ 1.7 per cent leaf potassium content. Potassium-deficiency decreased leaf potassium content but increased calcium, magnesium and phosphorus content. A close correlation was found between leaf potassium concentration and plant productivity.

Jørgensen (1976) pointed out in his seven year trials on carrot response to nitrogen, phosphorus, potassium and magne sium grown in rotation on 2 types (deep humus and sand humus) of reclaimed soil. Response to fertilisers occurred in the sand humus soil. Only P_2O_5, at the rate of 16 and 32 kg/ha enhanced the yields of saleable roots. Storage losses in carrot were not influenced by any of the fertiliser treatments. However, the results were non-significant.

Solov'ev and Solov'ev (1977) found, at Moscow, that nitrogen enhanced the carrot yield more than did phosphorus and potassium, but effectiveness of nitrogen fertilisers was enhanced by applying them in conjunction with phosphorus or potassium. Complete fertiliser (NPK) produced the highest yields. Nitrogen fertilisers alone decreased the carbohydrate content. Potassium fertilisers, in conjunction with nitrogen, increased the carbohydrate and protein content.

Nasur and Lukasmuk (1977) reported the beneficial effect of mineral fertilisation on the yield of white and yellow carrots. Mineral fertilisation increased the yield of yellow carrots by 16-38 per cent and that of white carrots by 3-85 per cent in field trials. Nitrogen had the greatest effect on yield of yellow and white carrots, followed by phosphorus and lastly by potassium.

According to Hipp (1978) working in South Texas (U.S.A.), carrots grown for 128 days showed yield response to applications of 56 or 112 kg N/ha. Application of 168 kg N/ha did not improve yields over the 112 kg N/ha rate.

Dragland (1978) studied the nitrogen and water requirement of carrot. Carrots subjected to a 3 week drought period at an early (2-leaf) stage produced more root and less leaf, compared to fully irrigated plants. Drought prior to harvesting caused some reduction in yield and an increase in dry matter and sucrose content of the roots, which tasted sweeter. Nitrogen at 40 kg/ha gave higher yield than nitrogen at 0 or 80 kg/ha. 80 kg N/ha led to increased nitrogen and nitrate contents in the roots. Storage life was not affected by any treatment.

(b) Radish

According to Purewal (1957), an application of 40-50 kg nitrogen, 40-50 kg phosphoric acid and 80-100 kg potash/ha was required by radish for increased yield.

Laske (1962) concluded that 100 quintals of radishes remove 50 kg N, 20 kg P_2O_5 and 50 kg K_2O and 30 kg CaO/ha. Hence crop should be properly manured for high yield.

Roy and Seth (1971) reported the beneficial effect of nitrogen, phosphorus and potassium on the nutrient uptake and quality of radish (Japanese white). Nitrogen at the rate of 60 or 120 kg/ha, P_2O_5 at 30 or 60 kg/ha and K_2O at 30 or 60 kg/ha were applied. The highest dose of nitrogen and phosphorus increased the uptake of these elements and nitrogen, phosphorus and potassium contents of roots and tops. Increases due to fertiliser applications were more marked when half the fertiliser was foliarly applied.

Haq and Khan (1972) conducted a 3 year trial in Pakistan on radish. The crop receiving 30 or 60 lb N/acre and 0 or 30 or 60 lb P_2O_5/acre. They found that the fresh root yield was greatest in response to 60 lb nitrogen and 30 lb P_2O_5/acre, whereas seed yield was maximal in response to 30 lb N/acre.

Pirovicki and Dyankova (1973) reported in 3 year trials at Bulgaria that all combinations of nitrogen, phosphorus and potassium fertilisers increased yields compared with the control. The highest total and marketable crop was produced by the application of nitrogen + phosphorus + potassium. Mineral fertilisers gave better results than equivalent organics.

Burdine (1976) observed in his sand culture experiments in Florida (U.S.A.) that using nutrient solution and containing 210 ppm nitrogen as ammonium and or nitrate showed that supplying 13-30 per cent of the nitrogen as ammonium was beneficial. Toxicity symptoms from excess ammonium were leaf cupping and chlorosis.

Borisov et al. (1977), working in the flood plains of the rivers Maskva and Okva, (U.S.S.R.) observed that 90 kg N + 60 kg P_2O_5 + 120 kg K_2O gave the best results and increased radish yields by 33-37 per cent as compared with the no-fertiliser control.

Shimada et al. (1977) studied the effect of ammonium chloride, as fertiliser, on radish in both a wet and dry year. The yields were as good or better than those obtained with ammonium sulphate or urea. The chloride fertiliser increased electrical conductivity values and the content of chloride in the plants, but no injury was apparent. The pH of the soil was the same as that on the plot treated with ammonium sulphate and lower than that on the urea plot, concentrations of calcium and magnesium in the tops were higher with ammonium chloride than with the sulphate.

Maurya _et al._ (1977) noted the effect of nitrogen and boron fertilisers applied as ammonium sulphate and borax at 0-200 kg N/ha and 0-3 kg borax/ha in all possible combinations, on growth and yield of radish. They noted that best results were obtained with both nutrients together, each at its highest level.

Nordestgaard (1978,a) studied the response of radish varieties to different nitrogen sources. Nitrogen at 100-120 kg/ha gave good yield. No difference in yield response was observed between nitrogen sources.

(c) _Turnip_

According to Thapar (1960), turnip requires more phosphorus and nitrogen than potash. Before the sowing, field should be properly manured with 20-25 metric tons of farm yard manure. Later, 60 kg nitrogen, 40 kg phosphorus and 40 kg potash/ha should be added through fertilisers for good yield.

Peith *et al.* (1969), while working in Northeast Scotland, (U.K.) reported the phosphate requirements of Swedish turnips from soil phosphate values. They calculated the correlation co-efficient between the responses of turnips to 120 lb P_2O_5/acre and readily soluble phosphate values for the soils, determined by 6 methods. There was marked effects of soil parent material and drainage on the correlation, which ranged from -0.05 to -0.74.

Delvalle and Harmon (1970) studied the effect of various nitrogen levels and sources on turnip in Tifton (U.S.A.). Nitrogen, supplied as sodium nitrate, ammonium sulphate and ammonium nitrate and ranging from 40-160 lb N/acre significantly increased yield, leaf blade weight, nitrogen content and improved the colour. The best yield was obtained with a split application of 160 lb N/acre.

Bradley *et al.* (1973) studied turnip response to nitrogen fertilisers and plant spacing. Application of 120 lb N/acre increased yields markedly at all row spacings. Increasing the seeding rate raised yields at each row spacing when 120 lb N was applied, but had little effect when 60 lb N was used. The heaviest seeding rate (9 lb/acre) elevated yields somewhat in the 7.5 and 5 inch rows.

Sharma *et al*. (1976), in their 3 year study found that nitrogen as sulphur coated urea (SCU), resulted in differences in turnip response, which were related to 3 different nitrogen release rates (A = 18%, B = 27% and C = 38%), SCU - C performed best in terms of yield.

Shimada *et al*. (1977) reported that turnip response to ammonium chloride as fertiliser was better than either ammonium sulphate or urea as source of nitrogen, as mentioned earlier in connection with radish.

2.6 NPK effect on growth and yield of green (leafy) vegetables

(a) Lettuce

Beckenbach *et al*. (1941) while working in sandy soil of Florida (U.S.A.) recommended for crisp head lettuce, nitrogen from 60 to 90 lb/acre, whereas phosphorus and potash requirements were found to be extremely variable.

Griffths and Finch (1945), working in the valley lands in Arizona (U.S.A.), suggested that, in fertile soil, 70 lbs P_2O_5 be applied in bands at planting time and 20 to 30 lbs of nitrogen be applied latter as side dressing. However, they found that application of potash did not influence the growth.

According to Mehta (1959) in Uttar Pradesh lettuce required nitrogen at the rate of 75 kg/ha and potash at 50 kg K_2O/ha for better yield. These levels could be applied to it by 25 to 37.5 metric tons of well rotted farm yard manure, ammonium sulphate and potassium sulphate.

Bishop *et al.* (1973) made observations on head lettuce grown on sphagnum peat at Kentville (Canada). They observed that nitrogen, phosphorus and potassium approximately at the rates of 180, 40 and 150 kg/ha, gave good yield.

Bastelaere (1973) conducted 2 trials on the NPK requirements of lettuce grown on peat. The highest yields were obtained by adding 0.5-1 kg ammonium nitrate, 0.5 kg superphosphate and 0.4 kg potash/m^3. Additional NPK did not enhance yield.

Silva *et al.* (1973), working with different sources and levels of phosphorus on lettuce, applied thermophosphate, superphosphate, triple-superphosphate and arax phosphate at 200 or 400 kg P_2O_5/ha. They concluded that neither the phosphate source nor the levels of P_2O_5 had any effect on yield.

Bastelaere (1974) studied the effect of NPK on lettuce grown an amended peat substrate in pot experiments, giving basic treatments of 0.5 or 1.0 g N, 0.5 or 2.0 g P and 0.5 or 1.0 g K/plant. He found that differences in response to differential nitrogen and phosphorus levels were slight but higher potassium level gave better results. In another trial he found that 1.0 g K/plant gave the best results. With most nitrogen, potassium combinations 0.5 g P/plant was adequate.

Hofmann (1975) obtained good results with early lettuce, when fertiliser nitrogen, and potassium were supplied through sprinkler system. The sprinkler applications increased yield by 6.6 and 12.5 per cent respectively as compared to soil-applied fertilisers.

Hamilton and Bernier (1975) studied the effect of NPK on the yield, composition and residues of lettuce grown on an organic soil in Quebec (Canada). 4 year period of cropping showed, potassium as the primary nutrient to be first in short supply for lettuce. Yields were depressed on the addition of nitrogen, phosphorus, and potassium in the first year of experiments, and subsequently did not respond significantly. After 4 year cropping without the addition of commercial fertilisers, the average yield for lettuce was 2.03 t/ha. The percentages of a total nitrogen, phosphorus and potassium taken up by the whole plants were 34.9, 47.9 and 26.7 per cent respectively.

Borkowski *et al.* (1975) studied the effect of different levels of fertilisers on growth of lettuce grown on a high peat substrate, which received NP basal dressing plus potassium at 300-1, 200 mg/l of substrate. 1,000-1, 200 mg/l slightly retarted the plant growth, but optimum potassium and nitrogen rates were 500-800 mg/l and 150-300 mg/l respectively, with an N:K ratio of 1:2.5-4.0. When N:K ratio was 1:1, marked deterioration in lettuce quality was noted. Increasing potassium rates raised plant potassium content but that of magnesium decreased.

Maxon (1976), working on nutritional requirements of lettuce grown under glass house conditions, provided solutions containing 200 ppm nitrogen, 150 ppm potassium and 0 or 15 ppm phosphorus at weekly, fortnightly or monthly intervals. He found, that in one trial, seed yield was greatest in treatments receiving phosphorus in weekly applications, but in other trials, seed yields were highest where phosphorus was not given. He also found that phosphorus had different effects on seed weight in the two trials.

Wilson (1976) reported with winter lettuce in Newzealand, that lettuce receiving phosphorus at the rate of 100, 200 or 300 kg/ha gave good results. Maturity was advanced and yields increased by phosphorus at the higher levels.

According to Oijen (1978), an additional application of nitrochalk at 5-20 kg N/acre on the incidence of glassiness disorder assessed at intervals, upto 39 days after planting. The disorder was greatly reduced by nitrochalk at all application rates, 15 kg/acre being the most economically effective. Lettuce head size, as indicated by the 100-head weight, was not adversely affected.

Tafuri _et al_. (1978) made observations that lettuce yield did not increase as the K_2O content of the nutrient solution was increased from 36 ppm to 360 ppm. The percentage content of soluble sugars in the tops (on dry weight basis) was about twice as high with 36 ppm and 144 ppm K_2O as it was with 252 ppm and 360 ppm.

Gardner and Pew (1979) studied the effect of various nitrogen sources on the winter grown head lettuce. Nitrogen was supplied as ammonium nitrate, ammunioum sulphate, calcium nitrate. Nitrogen source did not affect yield, quality, head size or total nitrogen accumulation.

At temperatures below 13°C, plant growth and nitrogen accumulation were similar with all nitrogen sources, but when low temperatures continued for about a week, nitrogen uptake and plant growth was sharply reduced.

(b) Spinach

Singh and Joshi (1960) recommended 25 cart loads of farm yard manure, followed by top dressing of ammonium sulphate, each being 100 kg/ha.

According to Singh (1961) for spinach, the field should be properly manured with 20-25 cart loads of farm yard manure. For a good yield of spinach he recommended that 60-65 kg ammonium sulphate/ha should be applied.

Cervato (1969) recommended that for a good yield NPK should be applied at the rate of 46 kg nitrogen, 12 kg P_2O_5 and 23 kg K_2O when the crop was spring sown. The total nitrogen was raised to 65 kg and the total K_2O to 66 kg/ha when the crop was autumn sown. These recommendations were based on results of a 4 year trial on spinach.

Maynard (1970) studied the effect of nutrient stress on the growth and composition of spinach at Mass (U.S.A.). He reported that nitrogen stress caused a general restriction in growth.

Leskovec and Dobersek (1972) applied various nitrogen rates on spinach. They found that nitrogen at 120 or 180 kg/ha increased yield in two spinach varieties, Vital R and Matador. The higher nitrogen rate raised the nitrate content of the dry matter in Vital R from 0.178 to 0.633 per cent and in Matador from 0.233 to 1.103 per cent.

Stanilova et al. (1972) noted the effect of nutrition on the chemical composition of spinach. In pot experiments with Matador variety, they observed that fertilising with nitrogen alone greatly increased the crude protein and the calcium and magnesium content. Fertilising with phosphorus alone increased the phosphorus and potassium content and decreased the nitrogen, calcium and magnesium content.

Choudhury et al. (1974) studied the effect of different levels of nitrogen and different spacings at Bangladesh. The fertiliser was supplied nitrogen at the rate of 20, 40 or 60 lb/acre. The yield of spinach significantly increased with closer spacings and higher nitrogen levels.

Bhore and Patil (1978) reported the efficiency of soil and foliar applications of nitrogen on yield of spinach. They concluded that soil plus 2 foliar nitrogen application gave the best results (250 q/ha compared with 85 q/ha for no-nitrogen control).

Nordestgaard (1978,b) studied the response of spinach to different nitrogen forms, levels and row spacings. A rate of 120-140 kg/ha was optimum for good yield but there was no difference between nitrogen forms.

2.7 NPK effect on growth and yield of okra

Singh (1962) found at Delhi that applying 250 q farm-yard manure/ha and then 1½ q ammonium sulphate by top dressing before fruiting ensured good yield of okra.

Janardhanam and Satyanarayana (1968) studied the effect of NPK and spacings on growth of okra at Hyderabad (Andhra Pradesh). They concluded, that increased fertiliser levels increased the rate of growth but it was not accelerated by wider spacing. Enhanced fertiliser levels with wider spacing, however, increased yield.

According to Randhawa (1969), nitrogen at the rate of 66 kg/ha gave good growth of okra. Hipp *et al.* (1971) pointed out at Welsecaco (U.S.A.) that phosphorus applied in combinations with zinc gave the highest yields of okra.

Sharma and Shukla (1973) studied the effects of NPK on okra on at Bangalore. Nitrogen applied as urea at 40-120 kg/ha, P_2O_5 as super phosphate at 17.44-52.32 kg/ha and K as muriate of potash at 24.9-74.7 kg/ha. The highest yields were obtained with nitrogen at 120, P_2O_5 at 34.88 and potassium at 49.8 kg/ha.

Chauhan and Gupta (1973) studied the effects of NPK on growth and development of okra. Plant height and girth, number of leaves and yield of green pods were increased by increasing applications of nitrogen (22.5, 45.0 or 67.5 kg/ha.). Whereas, phospherus at 22.5 or 45.0 kg/ha and potassium at 22.5 kg/ha had no effect on growth or yield. NPK applications, however, generally increased yields.

Verma *et al*. (1974) reported the beneficial effect of nitrogen on okra applied as foliar sprays and through soil. The highest yields were obtained from nitrogen at 150 kg/ha applied in the proportion of 3 foliar sprays: 1 soil application. Leela *et al*. (1975) also reported the beneficial effect of nitrogen and phosphorus on okra applied as foliar sprays and through soil. The foliar sprays resulted in highest nitrogen content of leaf. The yield was best at 125 kg N/ha, but higher rate of phosphorus was of no advantage. Saimbhi *et al*. (1975) studied the combined effect of phorate and nitrogen on the growth of okra. Nitrogen in combination with phorate had significant effect on growth.

Randhawa *et al.* (1977) observed in their 2 year pot experiments with okra cvs. Pusa Sawani and Punjab No.13 that phosphorus at 0-60 ppm, alone or in all possible combinations with zinc resulted in increased plant height, average pod number and weight of plant by applying each nutrient at the highest rate.

2.8 Conclusion

Thus, it is clear from the above brief review of literature that there is considerable variation regarding the optimum dose of fertiliser for these crops not only from country to country but also from one agroclimatic region of the same country to another.

As mentioned earlier, these are important crops of the area around Aligarh but no systematic research has been done on their fertiliser requirements, under the conditions prevailing in this part of Uttar Pradesh. An intensive study of the effect of various combinations of fertilisers on the growth, NPK content and yield of selected newly evolved varieties of carrot, lettuce, okra, radish, spinach and turnip so as to establish the optimum dose for highest economic yields under local conditions to be recommended to the farmers is, therefore, highly desirable.

In addition, it seems advisable to investigate if costly fertilizer could be saved by replacing a major portion of basal fertilizer with small doses applied by foliar spray at the proper time.

CHAPTER III

PROPOSED STUDY

CONTENTS

3. PROPOSED STUDY

It is proposed to conduct field experiments on the following new varieties of the selected vegetables to assess their NPK requirement and to study the feasibility of fertiliser economy, by using the technique of foliar nutrition, so as to cut down the cost of production, if possible.

(1) Carrot (*Daucus carota* L.)

(a) Pusa Kesar (Pocha's)

(b) Indian Long Red "

(2) Lettuce (*Lactuca sativa* L.)

(a) Big Boston (Pocha's)

(b) Wayahead "

(3) Okra (*Abelmoschus esculentus* Moench.)

(a) Long Green (Sutton's)

(b) Pusa Sawani "

(4) Radish (*Raphanus sativus* L.)

(a) Scarlet Globe (Sutton's)

(b) Pusa Reshami "

(5) Spinach (*Spinacia oleracea* L.)

(a) Long Standing Bloomsdale (Pocha's)

(b) Savoy "

(6) Turnip (*Brassica campestris* Var. rapa L.)

(a) Early Snow ball (Sutton's)

(b) Golden Ball "

The field trials for carrot, lettuce, radish, spinach and turnip will be performed in early winter (September to November) while those for okra, in late winter (February to March) at the Botanical Garden of the Aligarh Muslim University, Aligarh.

3.1 Preparation of the field: Before the start of each experiment, the field will be prepared by employing the usual methods required for vegetable growing. In addition to the inorganic fertilisers planned for the experiments, a uniform basal dressing of well rotted farm yard manure will be applied to the field at the rate of 75 q/ha.

3.1.2 Soil characteristics: Small soil samples will be collected at a depth of 15 cm from every plot before starting each experiment. A composite sample will be prepared, and analysed for various physico-chemical properties before each sowing.

3.2 Raising, transplantation of seedlings and harvesting: Proper nursery management and transplanting are important operations in vegetable production especially for crops requiring transplantation. Authentic seeds obtained from authorised seed dealers will be tested for viability and germinability. They will then be surface sterilised with ethyl alcohol before sowing.

The following practices will be used for the different crops during the course of study.

(a) Carrot

Carrot seeds will be sown on ridges (45 cm apart) directly. The seed rate will be 20 kg/ha. However, after the germination and establishment of the plants, thinning will be done to maintain plant to plant distance of about 5 cm. The developing roots will be covered with soil to prevent discoloration. Harvesting will be conducted when the roots will be about 2.5-3.5 cm in diameter at the upper end by pulling them out with the help of their tops. Total yield will be calculated at the time of final harvest.

(b) Lettuce

As germination is only about 50 per cent in this green vegetable, enough seed (40 kg/ha.) will be used for sowing. After one month of sowing, the plants will be transplanted in the field. Harvesting will be started after 35 days of transplantation, and the following cuttings will depend on the number and size of the leaves. Fresh yield will be calculated after the final cutting.

(c) Okra

It will be sown in February. The seed rate will be 14 kg/ha. Seeds will be sown directly in furrows 30 cm apart. Two seeds will be sown at one place and later on, one weak plant will be removed. Plant to plant distance will be maintained about 12 inches. Harvesting will be done at intervals (7 days) after the first picking. The pods will be picked when they are tender and their tips break on being bent a little.

(d) Spinach

Although the per cent germination is good in this vegetable, the seed rate will be maintained high 40 kg/ha, because about half the plants produce male flowers which are poor growers and will be uprooted as and when detected. Although the seeds may be sown by broad-casting, in the present study sowing will be done in rows 15 cm apart. Harvesting will be started after 3 to 4 weeks of sowing and subsequent cuttings will be done after 15 days until flowering. The yield will be calculated like that of lettuce after the final cutting.

(e) Radish

As the seeds of this crop show good germination, the seed rate will be kept 12 kg/ha. They will be sown directly in rows 23 cm apart. The seeds will then be covered by soil which will be made firm around them. The crop will be harvested when the roots are tender and crisp. Yield will be calculated like that of carrot.

(f) Turnip

The seeds of this crop also exhibit good germination. Therefore, the seed rate will be kept 6 kg/ha. Like carrot and radish, it will also be sown directly in rows 30 cms apart. Thinning may be done, if required. Turnips will be harvested when they will be about 7.0-9.5 cm in diameter. Yield will be calculated as in carrot and radish.

3.3 Experiment 1

This experiment will be laid out according to a factorial randomised block design. The aim of this field trial will be to select one promising variety each of carrot, lettuce, spinach, radish and turnip and to establish the basal inorganic fertiliser dose for their optimal performance under local conditions. The following combinations of nitrogen and phosphorus will be applied to the soil after the preparation of the field:

N_{100} P_{20}

N_{100} P_{40}

N_{125} P_{20}

N_{125} P_{40}

N_{150} P_{20}

N_{150} P_{40}

Thus, basal fertiliser treatments will comprise of three nitrogen doses (100, 125, 150 kg N/ha) and two phosphorus doses (20 and 40 kg P_2O_5/ha).

Nitrogen will be applied as urea and phosphorus, as superphosphate. Potassium will not be given as it is already present in sufficient amount in our experimental plots (Afridi, unpublished).

3.4 <u>Experiment 2</u>

Two varieties of okra will be tested giving the same fertiliser doses as in the Experiment 1. This experiment will follow the first experiment in the same year as sowing time of okra will be February. The aim of this trial will be the same as that of first experiment and it will also be laid out according to factorial randomised block design.

3.5 Experiments 3, 4, 5, 6, 7 and 8

These trials will be conducted during the second year and will be based on the statistical analysis of the findings of the earlier two experiments. The optimum dose thus established for each crop will be supplied partly as basal dressing and partly as top dressing (once after one month of sowing or transplanting). The other details will remain the same as in Experiments 1 and 2. Thus, the second year study will be divided into six experiments, one on each variety. The aim of these experiments will be to compare the effect of various split doses of basal and top dressing of fertilisers on growth, nutrient content and yield of each crop. For this purpose, the schedule of fertiliser application will be as follows:

	Treatments			
	Basal dressing		Top dressing	
S.No.	N	P	N	P
1.	1/2	1/2	1/2	1/2
2.	3/4	3/4	1/4	1/4
3.	Full	Full	Nil	Nil

The plants will be sampled for their growth characteristics and NPK content before top dressing and two weeks afterwards. The final yields will be calculated after the completion of harvest. The experiments will be based on simple randomised block design.

3.6 Experiments 9, 10, 11, 12, 13 and 14

During the final year six, experiments will be conducted on the basis of the statistical analysis of Experiments 3 to 8. The optimum combination of basal and top dressing selected for each crop in Experiments 3 to 8 will be kept as control. The remaining treatments will consist of full, 3/4 or 1/2 of the basal dose of this optimum combination plus 20 kg N and/or 2 kg P_2O_5/ha applied as foliar spray to replace top dressing in the soil at the appropriate time. Thus the following combinations will be tried:

	Treatments			
	Basal dressing		Foliar application	
S.No.	N	P	N	P
1.	Full	Full	20 kg/ha	Nil
2.	"	"	Nil	2 kg/ha
3.	"	"	20 kg/ha	2 kg/ha
4.	3/4	3/4	20 kg/ha	Nil
5.	"	"	Nil	2 kg/ha
6.	"	"	20 kg/ha	2 kg/ha
7.	1/2	1/2	20 kg/ha	Nil
8.	"	"	Nil	2 kg/ha
9.	"	"	20 kg/ha	2 kg/ha
10.	Full	Full	Proper dose of N and P_2O_5 applied to the soil	

In these experiments also, the other details will remain the same as inExperiments 3 to 8. Routine method for pest control will be employed throughout the course of growth period. Weeding and irrigation will be done as and when required. The plants will be sampled for their growth characteristics and NPK content before and fifteen days after spray. The final yields will be noted at the time of harvest. The experiments will be based on simple randomised block design. The data of these experiments are expected to establish whether foliar spray or top dressing is preferable for optimum yields and if fertiliser economy could be achieved with better yield by adopting the foliar spray technique.

3.7 Sampling technique

5 plants will be picked up randomly from each plot at fortnightly intervals, until the maturity of the respective crops. Their average leaf number, fresh weight, dry weight and leaf NPK content will be noted in all crops. In addition, for root crops (carrot, radish and turnip), fresh yield of roots will also be calculated at the time of harvest. Additional samples will be collected before each top dressing or spray and fifteen days after such treatments.

3.8 Leaf analysis

The five sample plants from each treatment, picked randomly, will be cleared from dust or other adhering material. The roots will be cut off, and the fresh weight of the shoots taken. The samples will be dried for 24 hours in an oven maintained at 80°C, and their dry weight, taken. Fully mature and healthy leaf blades will be powdered fine enough to pass a 72 mesh screen. This leaf powder will be kept over-night at 70°C before digestion and subsequent analysis for its NPK content according to the method of Lindner (1944), with slight modifications given below:

3.8.1 Digestion of samples

Reagents

1. Concentrated sulphuric acid (Nitrogen free)
2. 30 per cent hydrogen peroxide
   (Nitrogen and preservative free)

100 mg of the dried leaf powder of each sample will be carefully transferred to a 50 ml Kjeldahl flask, and wet ashed in 2 ml of chemically pure sulphuric acid and heated for about two hours until the sample is broken down and partially dissolved. If nitrates are present, heating will be continued for about a minute after dense fumes have been given off to allow for complete reduction

of the nitrates by the organic matter itself. The contents will then turn black. After cooling the flasks for about 15 minutes, 0.5 ml of chemically pure 30 per cent hydrogen peroxide will be added dropwise and the solution will be heated again till the colour of solution changes from black to light yellow. After heating for about 30 minutes, the flasks will be cooled for 10 minutes and an additional amount of 3-4 drop of 30 per cent hydrogen peroxide will be added, followed by gentle heating for another 15 minutes, to get clean and colourless extracts. At this stage, care will be taken in addition of hydrogen peroxide because if added in excess there is possibility that it would oxidise the ammonia in the absence of organic matter. The peroxide digested materials will be diluted with double distilled water and will be transferred with 3 or 4 washings to 100 ml volumetric flasks and the volumes will be made up. For further analysis of nitrogen, phosphorus and potassium, as summarised below, aliquots will be taken from these sulphuric acid-peroxide digested samples.

3.8.2 Estimation of nitrogen

For the estimation of nitrogen in the samples the method of Lindner (1944) will be adopted.

Reagents

1. 2.5 N sodium hydroxide

2. 10 per cent sodium silicate

3. Nessler's reagent

A 10 ml aliquot of the peroxide-digested material will be taken in a 50 ml volumetric flask and the excess of acid will be partially neutralized with 2 ml of 2.5 N sodium hydroxide. 1 ml of 10 per cent sodium silicate will be added to prevent turbidity and then finally the volume will be made up. A 5 ml aliquot of this solution will be taken in 10 ml graduated test tube and 0.5 ml of Nessler's reagent will be added drop by drop, mixing thoroughly after each instalment. After adding distilled water to make up the volume, the contents will be allowed to stand for about five minutes for maximum colour development. The solution will be then transferred to a colorimetric tube and the optical density will be measured at 525 nm. A blank will be run with each set of determination. The reading of each sample will be compared with a calibration curve, obtained using known dilutions of a standard ammonium sulphate solution.

3.8.3 Estimation of phosphorus

Phosphorus in the sulphuric acid-per oxide-digest will be determined by the method of Fiske and Subba Row (1925).

Reagents

1. Molybdate reagent
2. Aminonaptha sulphonic acid.

A 5.0 ml aliquot will be taken in a 10 ml graduated tube and 1 ml molybdate reagent (2.5 per cent amonium molybdate in 10 N H_2SO_4) will be carefully added, followed by 0.4 ml of 1:2:4, aminonaptha-sulphonic acid, which will turn the contents blue. Distilled water will be added to make up the volume upto 10 ml and the solution will be allowed to stand for about 5 minutes after mixing thoroughly. Then it will be transferred to a colorimetric tube and the optical density will be read at 620 nm. A blank will be run for each determination. A calibration curve will be prepared by using known dilutions of a standard monobasic potassium phosphate solution.

3.8.4 Estimation of potassium

Potassium will be estimated using a flame photometer. 1 ml aliquot will be taken and read at 768 nm.

A blank will be run side by side. The readings will be compared with a calibration curve plotted for different dilutions of a standard potassium sulphate solution.

3.9 Statistical analysis and discussion of data

The results of each experiment will be subjected to statistical analysis, according to its design, to ascertain their significance.

The implications of the data of each experiment will be discussed in the light of other relevant information gathered in the present study and with reference to the studies carried out by other workers on these crops and other allied plants.

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